Geologic Map of the Rudo Quadrangle, Clearwater County, Idaho

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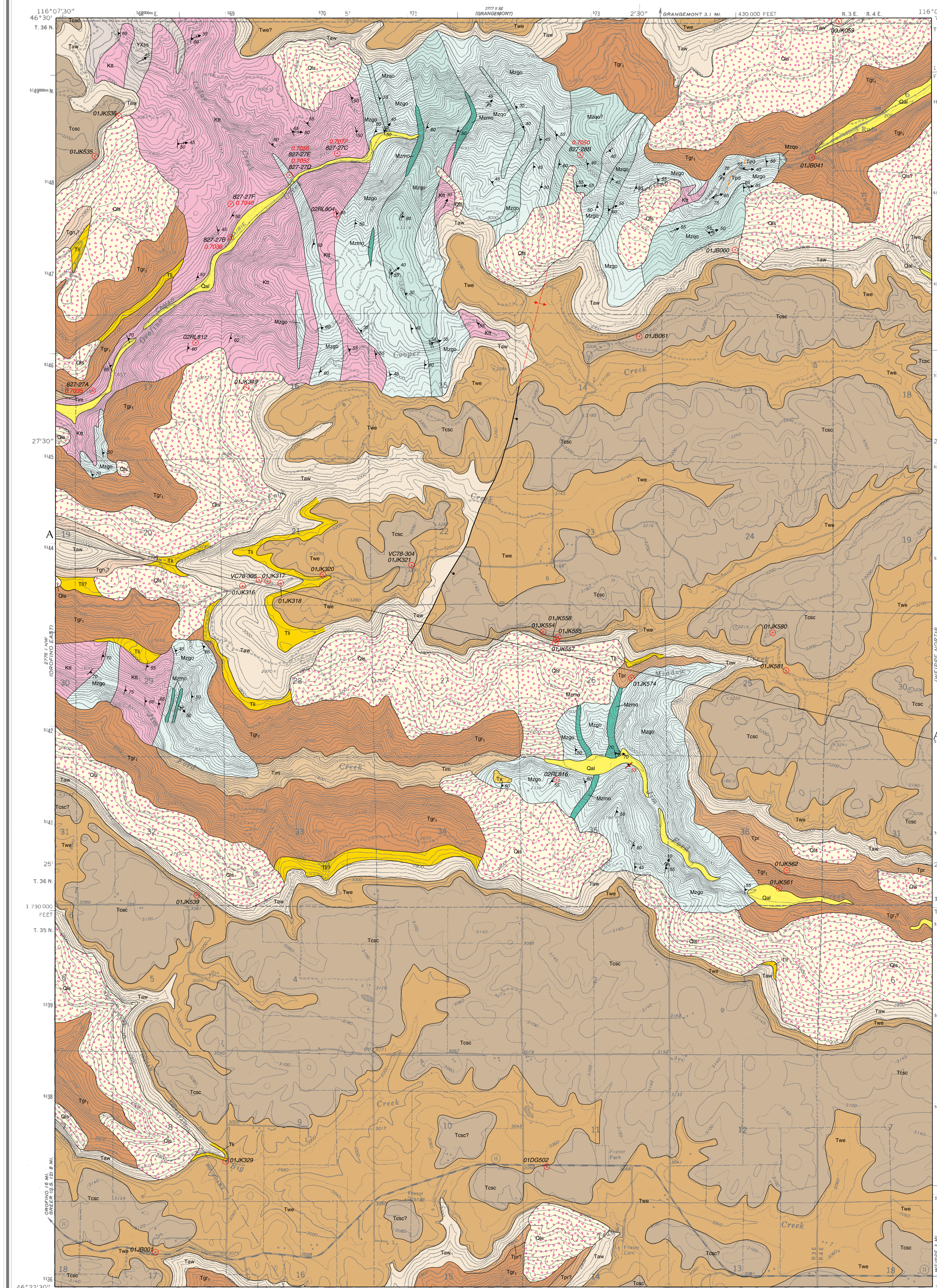
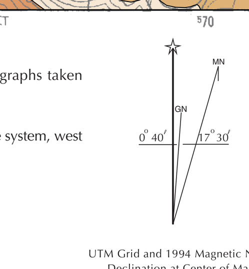
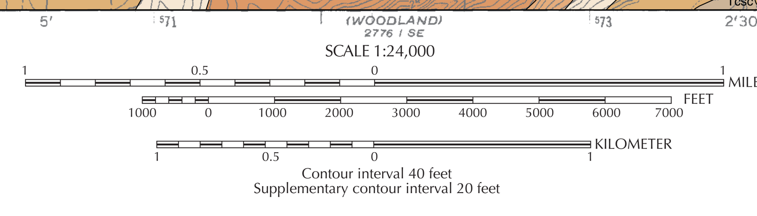
2005



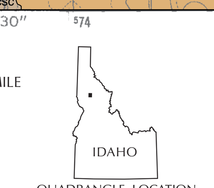


UTM Grid and 1994 Magnetic North Declination at Center of Map



SCALE 1:24,000

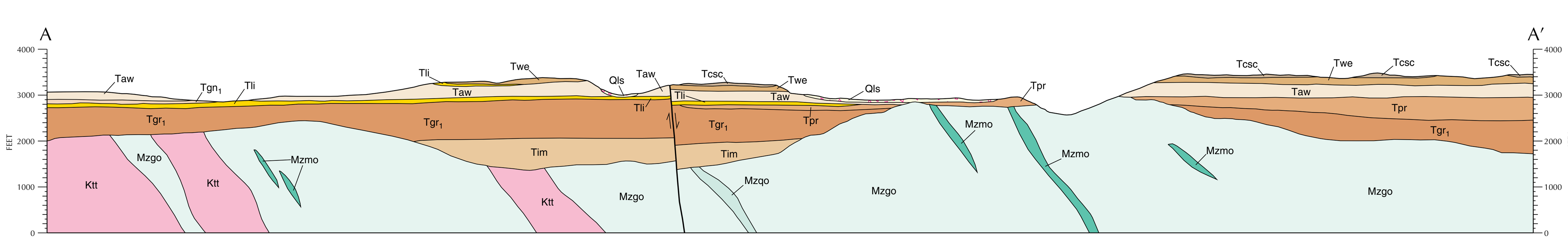
Contour interval 40 feet
Supplementary contour interval 20 feet



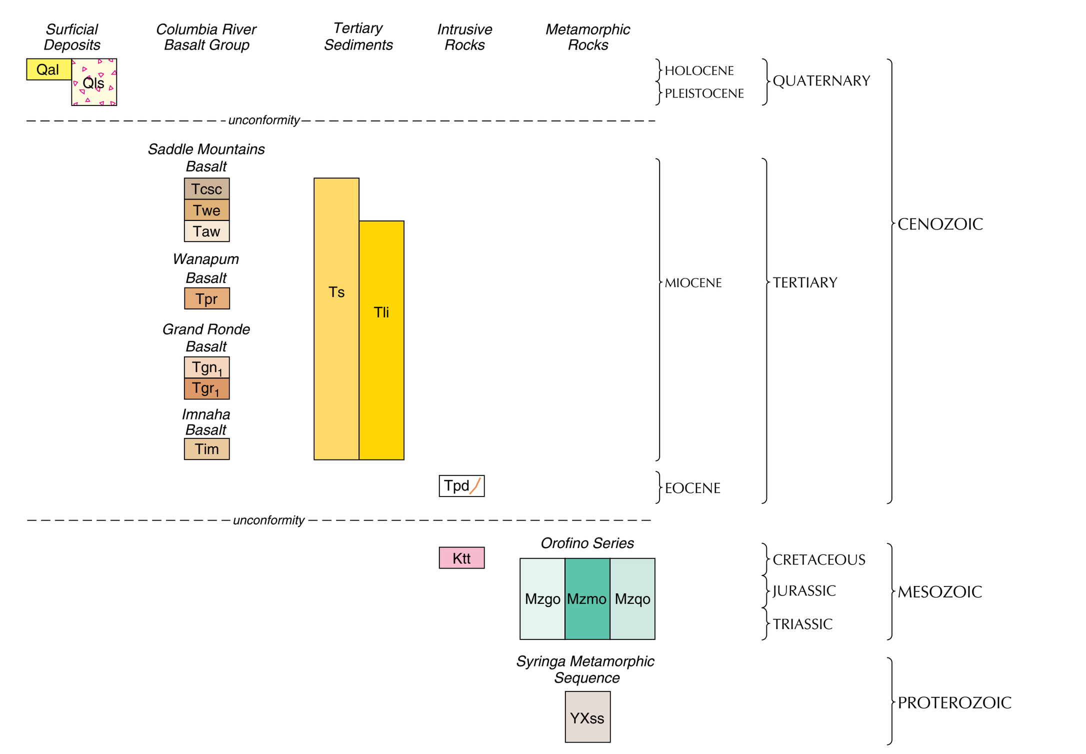
QUADRANGLE LOCATION

Base map from USGS digital raster graphic 1967.
Topography by photogrammetric methods from aerial photographs taken 1966. Field checked 1967.
1927 North American Datum.
Projection and 10,000-foot grid ticks based on Idaho coordinate system, west zone.
1000-meter Universal Transverse Mercator grid ticks, zone 11.
National geodetic vertical datum of 1929.

Field work conducted 2001 and 2002.
This geologic map was funded in part by the USGS National Cooperative Geologic Mapping Program and the Idaho Department of Lands.
Map reviewed by S.P. Reidel, Battelle, Pacific Northwest National Laboratory and S.A. Kattenhorn, Department of Geological Sciences, University of Idaho.
Digital cartography by Loudon R. Stanford, Jane S. Freed, and B. Benjamin E. Studer at the Idaho Geological Survey's Digital Mapping Lab.
Map edited by Roger C. Stewart.
Note on printing: The map is reproduced at a high resolution of 600 dots per inch. The inks are resistant to run but not to the fading caused by long-term exposure to light.
Map version 2-4-2005.



CORRELATION OF MAP UNITS



INTRODUCTION

The geologic map of the Rudo quadrangle is based on field work undertaken in the summers of 2001 and 2002. Basalt mapping relied partly on reconnaissance mapping and sampling from 1978 to 1980 (Swanson and others, 1979a; Camp, 1981). Prebasalt units were mapped using the 1:48,000-scale map of Hietanen (1962) as a starting point. We also had access to unpublished mapping by Gary F. Davidson (written commun., 2000). Numerous previously unmapped exposures were available because of new logging roads in the area. Descriptions of surficial deposits are based on those of correlative deposits on an adjoining surficial geologic map by Othberg and others (2002).

Basalt units were identified using hand sample characteristics, paleomagnetic signatures, geochemical signatures, and data from previous work. Representative samples of most basalt units were collected for analysis. These samples supplemented previous ones collected by V.E. Camp (written commun., 2002). Our sample locations and those of Camp are identified on the map. Analytical results are listed in Table 1. Intrusive rocks are classified according to IUGS nomenclature using normalized values of modal quartz (Q), alkali feldspar (A) and plagioclase (P) on a ternary diagram (Streckeisen, 1976). Mineral modifiers are listed in increasing order of abundance for both igneous and metamorphic rocks. Chemical analyses of two prebasalt units are listed in Table 2. Samples of basalt and prebasalt units were analyzed at Washington State University's GeoAnalytical Laboratory. Grain size classification of unconsolidated and consolidated sediment is based on the Wentworth scale.

DESCRIPTION OF MAP UNITS

QUATERNARY DEPOSITS

Qal **Alluvial deposits (Holocene)**—Mostly stream alluvium but may include some slope-wash and fan deposits. Primarily coarse channel gravels deposited during high-energy stream flow. Subrounded to rounded pebbles, cobbles, and boulders in a sand matrix. Moderately stratified and sorted. Includes intercalated colluvium and debris-flow deposits from steep side slopes.

Qls **Landslide and slump deposits (Pleistocene to Holocene)**—Poorly sorted and poorly stratified angular basalt fragments mixed with silt and clay. Landslide deposits include debris slides as well as blocks of basalt and sedimentary interbeds that have been rotated and moved downslope. Commonly form as a result of slumping of Latah Formation sediments.

TERTIARY SEDIMENTS

Ts **Sediment (Miocene?)**—Sediments on basement rocks. Age uncertain. Only mapped at one locality south of Jim Ford Creek in central part of map. Consists of basalt pebbles and cobbles.

Latah Formation

The Latah Formation consists of sediments associated with the Columbia River Basalt Group. On the Rudo quadrangle, they occur at the basement rock-basalt contact and within the basalt sequence. Equivalent to the Ellensburg Formation in Washington (Swanson and others, 1979b).

Tli **Latah Formation, sedimentary interbeds (Miocene)**—Sediment interbedded with basalt flows. Includes one exposure on basement north of Jim Ford Creek near the west edge of the map that is tuffaceous silt. Deposits include pebbles, cobbles, and clay; locally consist of tuffaceous deposits with an arkosic component. Areal extent of individual interbeds is probably greater than shown on the map. Thick interbed at the top of the R_1 generally poorly exposed and commonly slumped, forming a distinct bench along the south side of Jim Ford Creek. Soils on the bench contain arkosic sand detritus and commonly pebbles and cobbles. Many of the mapped landslides (*Qls*) originate in this interbed.

COLUMBIA RIVER BASALT GROUP

The stratigraphic nomenclature for the Columbia River Basalt Group follows that of Swanson and others (1979b) and used in Reidel and Hooper (1989). In Idaho, the group is divided into four formations. From oldest to youngest, these are the Imnaha Basalt, Grande Ronde Basalt, Wanapum Basalt, and Saddle Mountains Basalt. Imnaha Basalt occurs at the west edge of the quadrangle along Orofino Creek and along part of Jim Ford Creek. Grande Ronde Basalt has been subdivided, from oldest to youngest, into the informal R_1, N_1, R_2, and N_2 magnetostratigraphic units (Swanson and others, 1979b). Of these, only basalts from the R_1 and N_1 units were identified in the map area. The R_1 unit is exposed along the incised drainages of Jim Ford Creek and Orofino Creek and their tributaries. Grande Ronde N_1 Basalt is only found along the west margin of the map where it overlies a thick Latah Formation interbed deposited on R_1 basalt. The only Wanapum Basalt unit in the map area is the Priest Rapids Member, which crops out on the north side of Jim Ford Creek in the east part of the quadrangle. Saddle Mountains Basalt units, from oldest to youngest, are undivided flows of the Asotin Member and Wilbur Creek Member, the basalt of Weippe, and undivided flows of the basalt of Swamp Creek and basalt of Craigmont. These Saddle Mountain Basalt units occur across most of the quadrangle. Interbedded within the basalt sequence are sediments of the Latah Formation.

Saddle Mountains Basalt

Tcsc **Basalt of Craigmont and basalt of Swamp Creek, undivided (Miocene)**—Undifferentiated on the geologic map because of the similarity in chemical signatures, the close physical association, and the scarcity of outcrops. These units form the capping basalt in the Rudo quadrangle.

Basalt of Craigmont—Fine- to medium-grained phyric basalt with common plagioclase phenocrysts typically 2-5 mm long, rarely 7-10 mm long; scattered to uncommon olivine about 1 mm in diameter; some manganese(?) oxide cavity filling. Normal magnetic polarity, although field magnetometer readings are commonly inconsistent. Outcrops uncommon and generally poorly exposed. Probably consists of one flow with a thickness of 50-150 feet, possibly thicker locally. Commonly weathers to red-brown saprolite.

Basalt of Swamp Creek—Medium- to coarse-grained basalt with common plagioclase phenocrysts up to 10 mm in length and olivine phenocrysts a few millimeters in diameter. Normal magnetic polarity, although field magnetometer readings are commonly inconsistent. Similar chemically to Craigmont. Outcrops uncommon and generally poorly exposed. Probably fills structural and erosional depressions on older units. Poorly exposed, but at one location on the north canyon rim of Jim Ford Creek (sec. 26, T. 36 N., R. 3 E.), the basalt of Swamp Creek overlies the basalt of Weippe and is overlain by a basalt of Craigmont flow. Thickness not determined, but probably less than 75 feet. Commonly weathers to red-orange or red-brown saprolite.

Twe **Basalt of Weippe (Miocene)**—Medium- to coarse-grained basalt with some plagioclase phenocrysts 2-5 mm in length; abundant olivine crystals and clots generally visible to the naked eye. Reverse magnetic polarity, although field magnetometer readings are commonly conflicting and weak. Similar chemically to Pomona Member near Lewiston (Swanson and others, 1979a) and included in the Pomona Member by Camp (1981). Kauffman (2004) suggests the two units may not be coeval on the basis of paleomagnetic directions, although an age determination for the Weippe (12.9 ± 0.8 Ma; Kauffman, 2004) is not significantly different from the 12 Ma age reported for the Pomona Member by McKee and others (1977). Consists of one flow with a thickness of 100-150 feet, although may locally thicken to more than 200 feet over older structural depressions. Commonly weathers to saprolite. Typically overlies *Taw* unit, although locally may lie directly on basement rocks.

Taw **Asotin Member and Wilbur Creek Member, undivided (Miocene)**—Fine-grained basalt with scattered plagioclase phenocrysts 1-5 mm in length and a few olivine phenocrysts 1-3 mm. Upper part of flows commonly has abundant small spherical vesicles, many with a pale bluish coating. Includes the basalt of Lapwai, a subunit of the Wilbur Creek Member. Both members have normal magnetic polarity. Consists of one to three flows with a total thickness ranging from 100 feet to over 300 feet. Locally underlain by arkosic sediment, in places too thin or too poorly exposed to depict on the map.

Wanapum Basalt

Tpr **Priest Rapids Member (Miocene)**—Dark gray, fine- to coarse-grained basalt, dense to diktytaxitic, phyric with scattered equant crystals and laths of plagioclase as much as 5 mm in length and scattered to common olivine crystals 1-3 mm in diameter. Reverse magnetic polarity. Rosalia chemical type of Swanson and others (1979b). Found along upper Jim Ford Creek in the eastern part of the map where the unit overlies Tgr_1 flows or basement rocks. Also interpreted to be present along the southern flank of the quadrangle underlying Taw and overlying Tgr_1. The limited distribution and varied thickness of the Priest Rapids Member indicates it flowed into an area of irregular topography. It may have entered the quadrangle from the south because it is present in the adjoining Woodland quadrangle.

Grande Ronde Basalt

Tgn_1 **Grande Ronde, N_1 magnetostratigraphic unit (Miocene)**—Fine-grained, dark gray to black, aphyric to plagioclase-microphyric basalt. Normal magnetic polarity. Projected into the area from mapping on the adjacent Orofino East quadrangle. Probably one flow that pinches out along the west edge of the map.

Tgr_1 **Grande Ronde, R_1 magnetostratigraphic unit (Miocene)**—Typically dense, dark gray to black, fine- to very fine-grained aphyric to microphyric basalt. Less commonly medium grained with scattered small plagioclase phenocrysts. Reverse magnetic polarity, although field magnetometer readings commonly inconsistent and weak. Flows with thick entablatures form steep slopes or cliffs 100-200 feet high. Number of flows not determined, but the unit has a total thickness of about 800 feet.

Tim **Imnaha Basalt (Miocene)**—Medium- to coarse-grained, sparsely to abundantly plagioclase-phyric basalt; olivine common; plagioclase phenocrysts and clots as large as 3 cm common. In contact with pre-Tertiary basement rocks at exposure along Orofino Creek and Jim Ford Creek in the west part of the quadrangle. Outcrops are characterized by well-formed columns 1 to 3 feet in diameter and commonly fanning or radiating. Outcrops in nearby quadrangles have normal polarity.

INTRUSIVE ROCKS

Tpd **Porphyritic dacite dikes (Eocene?)**—Greenish gray, porphyritic dacite dikes. Only two mapped, both along the upper part of Orofino Creek. Phenocrysts are euhedral plagioclase laths 5-10 mm in length.

Ktt **Biotite tonalite and hornblende-biotite tonalite (Cretaceous)**—Biotite tonalite and lesser amounts of hornblende-biotite tonalite grading to hornblende-biotite quartz diorite. Includes one exposure of biotite granodiorite along the road west of Cedar Creek at the north edge of the map. Contains about 7-15 percent biotite and 0-10 percent hornblende. SiO_2 content of two samples is 63-64 percent (samples 02RL804 and 02RL812, Table 2). Initial $^{87}Sr/^{86}Sr$ values are transitional between low (<0.704) and high (>0.706) from west to east across the map area (Criss and Fleck, 1987). Their sample locations and values are noted on the map along Orofino Creek.

OROFINO SERIES

Amphibolite-facies metasedimentary (and metavolcanic?) rocks first recognized near Orofino (Anderson, 1930; Hietanen, 1962). Commonly sulfide-rich with iron-stained exteriors. Lithologically varied at outcrop scale. They appear to belong to the Wallowa accreted terrane assemblage, but they straddle the initial $^{87}Sr/^{86}Sr$ 0.704-0.706 line (Criss and Fleck, 1987) from Orofino to Kooskia. May be equivalent to parts of the Riggins Group (upper part of Squaw Creek schist?) exposed 100 km to the south and described by Hamilton (1963).

Mzgo **Hornblende gneiss (Mesozoic)**—Fine- to medium-grained hornblende-plagioclase gneiss. Contains plagioclase (10-69 percent), hornblende (10-35 percent), quartz (3-63 percent), pyroxene (0-12 percent), biotite (0-7 percent), garnet (0-5 percent), epidote (0-4 percent), graphite (0-3 percent), and sphene (1 percent or less). Includes minor calc-silicate quartzite containing about 50 percent quartz, 35 percent plagioclase, and various amounts of biotite, pyroxene, actinolite, epidote, graphite, and sphene. Uncertain protolith. Locally resembles amphibolite. Some of unit is clearly metasedimentary, but it may include metavolcanic rocks.

Mzmo **Marble (Mesozoic)**—Tan-weathering, white to light bluish gray marble in discontinuous lenses. Some beds are nearly pure calcite but most contain minor to moderate amounts of plagioclase, pyroxene, and hornblende.

Mzqo **Quartzite (Mesozoic)**—Mylonitic biotite quartzite and biotite-plagioclase-quartz schist. Contains 50-80 percent quartz, 10-35 percent plagioclase feldspar, and 0-7 percent biotite. Minor garnet, hornblende, pyroxene, actinolite, graphite, and sillimanite locally present.

SYRINGA METAMORPHIC SEQUENCE

Amphibolite-facies metasedimentary rocks first recognized east of Kooskia near Syringa (Lewis and others, 1992; Lewis and others, 1998). Regionally the sequence contains muscovite-biotite schist, clean quartzite, and calc-silicate rocks. Typically it is exposed east of the initial $^{87}Sr/^{86}Sr$ 0.704-0.706 line (Criss and Fleck, 1987) and is thought to be part of continental North America. In the Rudo quadrangle the Syringa sequence lies farther outboard (southwestward toward the accreted terranes) than elsewhere. This is either a result of fault slivers of Syringa rocks mixing with Orofino series rocks or the folding of the Syringa-Orofino contact. Biotite tonalite (*Ktt* unit) is intruded along the contact, obscuring the boundary relationships.

YXss **Schist and gneiss of the Syringa metamorphic sequence (Proterozoic)**—Medium-grained garnet-plagioclase-sillimanite-biotite-quartz schist. Exposed only in the northwest part of map. Garnet porphyroblasts are as large as 1 cm in diameter.

SYMBOLS

Contact: approximately located.

Normal fault: approximately located; dotted where concealed; ball and bar on downthrown side.

Fold axis.

Monocline: shorter arrow indicates steeper dips.

52 Strike and dip of foliation.

52 Strike and dip of foliation in narrow discrete zones.

80 Strike and dip of mylonitic foliation.

Strike of vertical foliation.

65 Bearing and plunge of lineation, type unknown.

40 Bearing and plunge of mineral lineation.

50 Bearing and plunge of small fold axis.

43 Bearing and plunge of asymmetrical small fold showing counterclockwise rotation viewed down plunge.

01DG502 Sample location and number.

0.7040 Initial $^{87}Sr/^{86}Sr$ ratio (from Criss and Fleck, 1987).

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Table 1. Major oxide and trace element chemistry of basalt samples collected in the Rudo quadrangle

Sample number	Latitude	Longitude	Unit name	Map unit	Major elements in weight percent: SiO_2	Al_2O_3	TiO_2	FeO*	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Trace elements in parts per million: Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th
00JK059	46.4997	-116.0132	Lapwai	Taw	51.74	15.31	1.75	11.02	0.172	9.62	6.230	1.25	2.51	0.385	92	143	30	262	605	24	261	191	38	14.3	20	50	106	8	30	67	3
01JK316	46.4440	-116.0983	Lapwai	Taw	52.62	15.18	1.787	11.03	0.171	9.39	5.57	1.30	2.53	0.416	60	114	30	273	674	26	266	202	42	17	20	32	104	16	42	74	11
01JK317	46.4445	-116.0947	Lapwai	Taw	52.54	15.26	1.753	11.22	0.168	9.60	5.36	1.24	2.46	0.392	62	132	27	280	641	28	269	197	40	15	18	37	105	14	46	54	9
01JK318	46.4443	-116.0929	Asotin	Taw	50.39	16.06	1.432	9.90	0.159	11.23	7.86	0.57	2.21	0.189	118	265	29	248	254	12	242	111	26	9	17	72	78	6	10	34	7
01JK320	46.4451	-116.0868	Weippe	Twe	52.12	15.24	1.776	9.92	0.205	11.31	6.25	0.43	2.54	0.212	47	70	38	303	279	7	248	122	31	11	19	50	93	5	9	46	5
01JK321	46.4461	-116.0742	Craigmont	Tcsc	52.29	13.49	2.997	14.20	0.394	8.46	3.54	1.43	2.76	0.428	33	34	33	403	742	30	294	253	49	24	22	33	136	12	42	75	3
01JK329	46.3873	-116.1007	Weippe	Twe	51.46	14.86	1.710	10.74	0.187	11.09	6.73	0.42	2.59	0.207	32	74	38	284	221	5	237	119	27	11	19	37	90	2	21	45	2
01JK349	46.4636	-116.0978	Asotin	in Qls (Taw)	49.98	16.26	1.412	9.71	0.159	11.38	8.24	0.45	2.25	0.163	131	284	32	243	188	7	245	98	26	10	18	74	71	5	38	28	3
01JK535	46.4866	-116.1196	Craigmont	Tcsc	51.12	13.35	2.949	15.41	0.247	8.28	3.99	1.43	2.81	0.422	29	34	30	378	640	28	287	251	49	26	24	33	129	10	47	83	2
01JK536	46.4903	-116.1160	Asotin	Taw	50.22	16.09	1.427	9.85	0.156	11.25	8.00	0.56	2.26	0.186	119	263	32	250	278	10	248	111	26	10	17	86	77	6	25	28	3
01JK539	46.4135	-116.1048	Craigmont	Tcsc	52.57	13.69	3.000	13.42	0.222	8.46	3.86	1.46	2.88	0.435	36	34	34	378	660	32	297	261	50	28	24	35	138	6	30	67	2
01JK554	46.4395	-116.0555	Craigmont	Tcsc	52.04	14.16	3.121	12.99	0.430	8.77	3.42	1.65	2.97	0.453	54	30	34	380	843	31	316	264	55	28	23	39	141	10	49	49	3
01JK555	46.4390	-116.0533	Swamp Creek	Tcsc	51.90	13.67	2.774	13.57	0.213	8.77	4.72	1.24	2.75	0.376	30	42	34	369	615	26	293	218	47	24	25	43	127	8	30	72	1
01JK557	46.4384	-116.0537	Asotin	Taw	50.10	16.10	1.414	9.67	0.160	11.29	8.35	0.52	2.24	0.156	128	278	36	254	258	8	239	102	24	10	19	79	75	5	32	14	3
01JK558	46.4387	-116.0536	Weippe	Twe	51.75	14.50	1.682	11.02	0.186	10.83	6.70	0.56	2.58	0.197	34	66	37	274	256	10	232	120	27	12	20	55	83	7	0	34	3
01JK561	46.4142	-116.0218	Grande Ronde R_1	Tgr_1	54.51	13.80	2.285	12.18	0.196	7.78	4.05	1.65	3.18	0.367	18	33	34	337	559	42	322	204	40	14	21	71	116	9	0	46	2
01JK562	46.4160	-116.0210	Priest Rapids	Tpr	50.18	12.82	3.644	15.22	0.246	8.58	4.46	1.36	2.69	0.791	15	35	44	434	577	32	286	217	51	18	20	17	143	7	44	57	4
01JK574	46.4350	-116.0429	Priest Rapids	Tpr	50.29	13.05	3.709	14.81	0.240	8.66	4.43	1.36	2.65	0.800	14	28	46	444	613	30	295	220	52	19	24	13	151	5	30	44	2
01JK580	46.4394	-116.0227	Craigmont	Tcsc	51.79	13.57	2.957	14.01	0.243	8.38	4.28	1.50	2.86	0.425	33	42	32	374	650	29	288	255	50	27	25	36	140	10	21	83	2
01JK581	46.4357	-116.0208	Weippe	Twe	50.34	14.68	1.942	11.95	0.202	10.84	6.89	0.39	2.52	0.253	34	63	36	299	294	5	242	137	32	16	19	50	93	8	22	41	1
01JB001	46.3784	-116.1107	Weippe	Twe	51.75	14.48	1.681	10.90	0.186	10.96	6.75	0.51	2.59	0.202	31	71	38	287	221	8	234	121	28	13	20	47	84	1	18	43	0
01JB041	46.4862	-116.0171	Grande Ronde R_1	Tgr_1	54.74	13.92	2.305	11.79	0.206	7.74	4.13	1.53	3.27	0.357	17	34	43	344	568	41	312	197	39	16	22	66	112	7	7	49	2
01JB060	46.4771	-116.0281	Wilbur Creek	Taw	53.35	14.71	1.877	11.56	0.174	8.73	4.85	1.68	2.60	0.476	50	80	32	273	811	34	270	226	43	18	19	24	114	16	55	93	9
01JB061	46.4686	-116.0417	Craigmont	Tcsc	53.15	14.37	3.154	12.01	0.207	8.81	3.38	1.50	2.98	0.446	27	37	41	396	724	31	307	266	55	29	25	37	145	9	36	72	3
01DG502	46.3868	-116.0549	Swamp Creek	Tcsc	52.00	13.47	2.760	13.90	0.324	8.92	4.30	1.22	2.72	0.378	37	49	36	371	507	27	282	212	44	23	23	42	131	5	35	79	5
**VC78-304	46.4461	-116.0742	Craigmont?	Tcsc?	50.60	14.38	2.85	15.59	0.28	8.24	3.55	1.45	2.49	0.38																	
**VC78-305	46.4446	-116.0960	Asotin	Taw	50.36	16.89	1.34	10.01	0.16	10.76	7.71	0.43	1.95	0.18																	

* Major elements are normalized on a volatile-free basis, with total Fe expressed as FeO.
** Samples collected by V. Camp in 1978. Analytical results used with permission (Camp, written commun., 2002).
Other analyses performed at Washington State University GeoAnalytical Laboratory, Pullman, Washington.

Table 2. Major oxide and trace element chemistry of basement rocks collected in the Rudo quadrangle

Sample number	Latitude	Longitude	Rock name	Map unit	Major elements in weight percent: SiO_2	Al_2O_3	TiO_2	FeO*	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	Total	Trace elements in parts per million: Ni	Cr	Sc	V	Ba	Rb	Sr	Zr	Y	Nb	Ga	Cu	Zn	Pb	La	Ce	Th
02RL804	46.4806	-116.0849	Hornblende-biotite tonalite	Ktt	63.78	17.27	0.624	4.25	0.087	5.15	2.07	2.38	3.55	0.197	99.36	4	10	15	94	980	74	577	174	16	13	20	1	74	11	33	53	9
02RL812	46.4680	-116.1050	Hornblende-biotite tonalite	Ktt	62.38	18.29	0.569	4.44	0.125	6.23	1.75	1.08	4.18	0.223	99.27	2	6	11	77	437	22	628	125	18	7	18	6	84	3	13	50	2
02RL816	46.4249	-116.0535	Epidote-pyroxene-hornblende gneiss	Mzgo	53.04	17.60	1.103	8.19	0.153	9.42	4.71	0.49	4.43	0.154	99.29	26	78	27	302	96	3	610	71	15	3	20	97	59	3	5	29	0

*Total Fe reported as FeO.
Analyses performed in 2002 at Washington State University GeoAnalytical Laboratory, Pullman, Washington.

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